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The impact of red giant mass loss on star cluster evolution

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Abstract. We discuss the importance for the long-term cluster evolution of the mass loss from intermediate-mass stars (0.8–8 $M_\odot$). We present constraints on the mass loss from red giants in clusters in the Magellanic Clouds, a search for the intra-cluster medium in galactic globular clusters, and a simple estimate for the cluster evolution due to red giant mass loss compared to stellar escape.

Figure 1. Spitzer Space Telescope 3.6+4.5+5.8 μm composite of ω Cen.

1. Introduction

The evolution of a star cluster depends critically on its ability or failure to retain its mass. Dynamical processes cause mass segregation and preferential escape of low-mass stars from clusters. Besides losing entire stars, clusters also lose mass due to envelope mass loss from its member stars, exacerbating cluster dispersal. We here briefly discuss the importance for the long-term cluster evolution of the mass loss from intermediate-mass stars in the mass range 0.8–8 $M_\odot$.

2. Mass loss in clusters in the Magellanic Clouds

We searched for circumstellar dust around giants in clusters of a wide range in ages in the SMC and LMC (van Loon, Marshall, & Zijlstra 2005). Such dusty 'superwinds' cause an infrared excess. The spectral energy distributions were modelled to derive mass-loss rates. We compared the integrated mass-loss rate with the total cluster mass. The timescale for a cluster to lose its mass through dusty superwinds is found to be not much longer than the cluster age. This is true for young clusters (10^{7-8} yr) as well as older clusters ($\sim 10^9$ yr). Hence, stellar mass loss can be important throughout the evolution of a cluster.

3. Intra-cluster medium in galactic globular clusters

Stellar mass loss continuously replenishes the intra-cluster medium. Detecting this material has proven difficult, suggesting efficient removal during the journey through the galactic plane and halo. Nonetheless, we recently detected 0.3 $M_\odot$ of neutral hydrogen in the intra-cluster medium of the galactic globular cluster M 15 (van Loon et al. 2006). Despite its low metallicity of [Fe/H]$= -2.2$, dust has also been detected in this cluster (Evans et al. 2003; Boyer et al. 2006).

4. Cluster evolution as a result of stellar mass loss

Mass loss from a star cluster can be written as

$$\dot{M} = cM.$$

If the mass loss is slow compared to the relaxation timescale, the process is quasistatic. Applying the virial theorem, the cluster radius would increase as

$$R(t) \simeq R(0)\ e^{3ct}.$$

For the case of stellar escape due to cluster dynamics: $c \sim \tau_{\rm relax}/136$. Relaxation timescales for globular clusters are typically $\tau_{\rm relax} \sim 1$ Gyr. Hence, after 10 Gyr the radius would have increased by ~ 25 per cent.

For a stellar initial mass function $dN \propto M^{-\alpha} dM$ with $\alpha \sim 2$, stars in the mass range 0.8–8 $M_\odot$ contribute at least as much to the initial cluster mass as lower-mass stars. In galactic globular clusters, with ages $t \sim 10$ Gyr, these intermediate-mass stars have all lost significant mass on the asymptotic giant branch. Assuming all this mass is removed from the cluster, we estimate that $ct \sim 0.3$. Hence, the radius will have grown by a factor ~ 3 over the last 10 Gyr.

We tentatively conclude that stellar mass loss could be more important for the evolution and survival of star clusters than dynamical effects alone.

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References

Boyer, M.L., Woodward, C.E., van Loon, J.Th., et al. 2006, AJ, 132, 1415
Evans, A., Stickel, M., van Loon, J.Th., et al. 2003, A&A, 408, L9
van Loon, J.Th., Marshall, J.R., Zijlstra, A.A. 2005, A&A, 442, 597
van Loon, J.Th., Stanimirović, S., Evans, A., Muller, E. 2006, MNRAS, 365, 1277